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AND ITS
ADMINISTRATIVE
CONTROL.

BY

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INFANT MORTALITY AND ITS ADMINISTRATIVE CONTROL.¹

By M. GREENWOOD, JUN.

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THE death of a child appeals in a peculiar way to the emotional side of human nature. Reason may satisfy us that the loss of a young man in the spring-time of his powers or of an adult during the period of full mental and physical vigour is really a greater tragedy, but we seem all of us, at least in the abstract, more touched by the pathos of death at the beginning of life. Most recall with tenderness the lines of Vergil:—

“Continuo audita² voces vagitus et ingens
Infantumque animae flentes in limine primo,
Quos dulcis vitae exsortis et ab ubere raptos
Abstulit atra dies et funere mersit acerbo.”

There was a time when a high rate of infant mortality seemed part of the settled order of the universe; a view expressed with his usual precision by T. R. Malthus, over a hundred years ago.

“And yet when we contemplate the insufficiency of the price of labour to maintain a large family, and the amount of mortality which arises directly and indirectly from poverty; and add to this the crowds of children which are cut off prematurely in our great towns, our manufactories, and our workhouses, we shall be compelled to acknowledge that if the number born annually were not greatly thinned by this premature mortality, the funds for the maintenance of labour must increase with much greater rapidity than they have ever done hitherto in this country in order to find work and food for the additional numbers that would then grow up to manhood.”²

¹ A lecture delivered at University College, London, on February 20th, 1912.

² T. R. Malthus, “An Essay on the Principle of Population,” 5th Edition, Vol. II., p. 49.

According to Malthus, 50 per cent. of all persons born in London died under the age of three years,¹ while the average mortality for the first year of life was, in Sweden, 25 per cent.

Period.	1730-49	1750-69	1770-89	1790-1809	1810-29
Percentage Deaths under 5 years.	74·5	63·0	51·5	41·3	31·8

As will be gathered from Table I., in our own times the rate of infant mortality is lower, but still very heavy in the most civilised countries. In the course of the last century public opinion respecting the subject of infant mortality has changed, under the influence of a variety of circumstances. In the first place the emotional aspect of child mortality has certainly not become less prominent; again, the diminution in effective fertility which has been noticed in greater or less degree almost universally has given rise in some minds to anxiety regarding the future of civilisation, an anxiety which has led to inquiries as to whether the effects of a falling birth rate might not be neutralised by a reduction of the infant death rate. Lastly, the triumphs of hygiene over many zymotic and contagious diseases, together with improvements in the whole art of medicine and surgery, have seemed to open up prospects of a successful onslaught upon infant mortality. At the present time, the opinion current in influential quarters might, I think, be summarised as follows :—

A certain number of deaths occurring in the first year of life are due to causes entirely beyond human control. Some children born with grave developmental anomalies of the circulatory or nervous systems are examples; some cases of premature birth are also instances. These cases, however, although absolutely numerous, form but an insignificant proportion of the whole number of infant deaths. The bulk of infant deaths are the result of bad feeding, bad housing, in-

¹ For earlier times we have : (see "*Vital Statistics*," by W. Farr, London, 1885, p. 195).

sufficient and unskilled attention, an unhygienic environment in the widest sense of the word.

The removal of these immediately destructive conditions is within the sphere of an enlightened system of public administration, and we may hope, with a sufficient expenditure of money, brains, and energy, enormously to reduce the present rate of infant mortality. In one sentence, a low or a high rate of infant mortality is *mainly* a matter of good or bad public health administration, actual or possible.

That I have not drawn an imaginary picture of opinions advocated by leading members of my profession is sufficiently demonstrated by the following quotation from a work, addressed to the general public, by the well-known physiologist, Professor Benjamin Moore, of Liverpool:—

“One person out of every five persons born dies before the fifth birthday is reached, and under proper conditions of sanitation at least 80 per cent. of these deaths could be avoided. Latin names figure in the returns of the Registrar-General as the cause of death, but in plain English the children die from dirt, ignorance, carelessness, and starvation. Also, sad to relate, there has not been the slightest improvement in this respect within the past 40 years. Neither is it possible to hug the fond delusion that these are weak, enfeebled children, to preserve whom would be detrimental to the race. These children who die are born healthy, and placed in similar circumstances any other children would succumb just as fast as these. The diseases of infancy fall upon the fit and the unfit; and epidemic diarrhœa or bronchitis caused by neglect after measles, kill the fit just as much as the unfit.”¹

I am not acquainted with the evidence upon which Professor Moore bases his estimate of 80 per cent. of deaths under five years of age due to preventible causes, but, in any case, I am only concerned to show that the view sketched above is held by educated medical men.²

Now, we should ask ourselves one question with regard to this doctrine, viz., is the evidence upon which it is based complete? An answer to this question would in no way commit

¹ Prof. B. Moore, “The Dawn of the Health Age,” London, 1911, p. 15.

² “Some of the principal causes [*i.e.*, of infant mortality] are improper and insufficient food, bad management, use of opiates, neglect, early marriages, and debility of mothers; but whatever may be the special agencies at work which are so prejudicial to infant life, it must be borne in mind that a high death rate is in a great measure also due to bad sanitary arrangements.” (Farr, *op. cit.*, p. 192.)

us to an opinion respecting the desirability of the measures advocated by social reformers with a view to diminishing the rate of infant mortality, but would help us to form a judgment as to the amount of success they may be expected to achieve under present conditions of society.

The object of this paper is to direct the reader's thoughts to some of the difficulties which arise in interpreting the evidence at present relied upon by medical inquirers. It is not within my power to remove or lessen these difficulties, but time spent in considering them will not be wasted. Paley, I think, remarked that it is often more troublesome to convince people that a difficulty exists than to show them how to remove it. Perhaps, if I can show that there really is a problem to be solved, some reader may succeed in discovering its solution.

Common sense indicates two great sets of phenomena which are of importance in gauging the chance a child will have of living through one year of existence. The first set comprises the events which precede its birth; the second consists of the post-natal conditions to which it must be exposed. Let us briefly notice these in order :—

(1) To begin with, we have the nexus of cause-groups summarised in common speech by such terms as innate characters, potential characters. We have also the effects which may indirectly be exerted upon the unborn child by the exposure of its mother to an unfavourable environment. For instance, if the mother be underfed or overworked, or both, the circumstances might react unfavourably upon the embryo. We may include here cases of germinal or placental infection, such as syphilis or congenital tubercular disease.

Passing now to (2), post-natal conditions, we have, as before, in the first place, the continued influence of innate factors, bone of the child's bone and flesh of its flesh, we have also the indirect reaction of the maternal characteristics, made manifest perhaps in an inability to suckle the child owing to anatomical or physiological shortcomings. But in addition to these we have the direct action of the environment upon the child itself, a factor which now becomes of striking and, upon superficial examination, overwhelming importance. A new-born child

seems, indeed, largely at the mercy of its environment. A physiological machine requiring for the satisfactory performance of its functions a set of conditions varying within but narrow limits, its powers of self-adjustment are of the slightest; thus it has yet to acquire the status of a homoiothermal animal, it needs a highly specialised food, and its means of self-defence are purely vocal. We see that the environmental factors of prime importance may themselves be ranged in two groups. On the one hand, we have to consider the kind of food provided, whether natural or artificial, if the latter, whether it be in quality and quantity approximating to that devised by nature; on the other hand, we have the environment in a more popular sense, including the kind of clothing and shelter as well as the quantity and quality of personal attention afforded by mother or nurse.

Very little reflection is sufficient to show that these environmental factors are themselves the resultants of a chain of causes difficult to isolate. Thus, consider the method of feeding. If the mother does not suckle her child, it may be because she goes out to work and has no time for nursing. If the action be solely conditioned by economic pressure, this cause might be removed. The solution is theoretically simple; let the State pay the family the sum which would have been earned by the mother had she been at work, on condition that she suckles the infant. But this presupposes that the type of the woman that goes out to work is in no way differentiated from that of her home-keeping sister. Perhaps the supposition is well founded, perhaps it is not. A similar ambiguity will be felt when we analyse any other environmental influence.

I have not, of course, given anything like a complete catalogue of the influences which are of importance to infant life. Still, if one considers even those I have named, it is sufficiently obvious that a complete study of the problem is a task of immense magnitude. For the present we must needs confine ourselves to a much humbler inquiry, and we must be critical of those who claim to have solved the whole problem of infant mortality. Let us, then, merely attempt to ascertain the relative importance of those factors which have at different times been

brought into prominence by medical and sociological writers. Of such factors, three have usually been accorded special attention, viz., the birth rate, the prevalence of poverty, the prevalence of artificial feeding. A few words must be devoted to each of these :—

The Birth Rate.—This is probably the factor which attracted notice first and its relation to the infant death rate, in the apprehension of Malthus and his immediate followers, may be inferred from the quotation I have already made. Their inference was that the population presses closely upon the means of subsistence, and that consequently the birth and death rates were bound together. It has therefore resulted that when a school of political thought arose which instilled a belief that, even in densely populated countries, the means of subsistence are more than adequate to sustain an enormously greater population than the existing one, the old train of ideas no longer went unchallenged. Even if we assume, however, that the Malthusian doctrine is economically and biologically false, it does not follow that the connection between the birth and death rates is accidental or non-existent. Suppose we sorted out our population into two mutually exclusive classes, one comprising the tuberculous, the criminal, the mentally ill-balanced, and in general all those families some members of which had exhibited a physical or mental stigma; the other class being formed of the rest of the population. Next let us suppose that the characters which distinguish the former group are the outward visible signs of some inward peculiarity, innate and heritable. Also let us suppose that the fertility of the first class is greater than that of the second. What consequences may be expected to ensue? If our tuberculous and insane stocks are so in virtue of an innately low resisting power towards the harmful elements of a common environment, we shall hardly be surprised if their offspring are in turn less fit to combat the ordinary dangers to which infants are exposed than are the children of normal persons; in other words, there would appear to be some correlation between fertility and infant mortality. It will be noted that the assumptions of a differential birth rate and of an heritable type, physiologically inferior to

the normal, are essential to this argument. It is unnecessary to observe that numerous publications by the staff of the Galton Laboratory have established a formidable case in support of both propositions. It is necessary to remark that the genesis of the higher birth rate among the less resistant stocks—assuming it to exist—is not a point the discussion of which is germane to my argument. I am only anxious to show that a correlation between the birth rate and the infant death rate *might* arise independently of the economic factor to the operation of which it is usually referred. I do not even go so far as to suggest that this is the real explanation, but merely plead for its being borne in mind when we come to discuss the whole problem.

The Poverty Rate.—The possible influence of bad economic conditions upon the fate of infants, I think I may say the *certain* influence of such conditions, hardly needs illustration. The difficulty in connection with this topic is to obtain a satisfactory measure of what we term poverty, a measure which will be appropriate for statistical use. This, however, is a subject which has attracted the notice of too many writers for it to be permissible to enlarge upon the difficulties here.

The Methods of Infant Feeding.—The evil possibilities of the feeding-bottle, the dangers of septic contamination and the relation between such contamination and the development of summer diarrhoea have often been noted. In addition, we should remark that the whole trend of modern physiological chemistry leads one to emphasize the specificity of animal secretions. Human milk can be prepared nowhere but in the human mammary gland, no chemical ingenuity will suffice to convert the milk of any other species into something “just as good.” Here, again, in a factor ostensibly environmental we detect the possible intervention of constitutional causes. As Prinzing remarks: “The causes are either disinclination on the part of the mother, social conditions, or a defective functioning of the mammary glands.”¹ It is obvious that physical characters, possibly heritable, may be here of great moment. This brief analysis of the popular explanations of a high rate of infant

¹ Prinzing, *Handbuch d. Medizin. Statistik*, p. 292-3.

mortality has sufficed to show that not one of the alleged causes can be regarded as exclusively environmental, and that, were we able to prove that any one of them takes definite precedence of the others as an effective cause, it would not be possible to assert that infant mortality is necessarily within the field of administrative control. At the same time, contenting ourselves with a somewhat superficial view, it might be said that the effects of public health administration are likely to be most marked in connection with the dangers of infant feeding, less plain in connection with poverty, and least of all with respect to the birth rate. The administrator can do a good deal to reform the milk supply, something towards improving the general conditions of life, but, even then he will hardly succeed in raising or lowering the birth rate.

It, therefore, would seem to follow that were we able to show that the rate of infant mortality is most highly correlated with the practice of bottle-feeding as at present carried out, less closely associated with the rate of poverty and least with the birth rate, we should have grounds for hoping that sanitary and administrative reform might ultimately reduce the infant death rate to some seven per cent. suggested by Westergaard as about the possible minimum.¹ Since the general average is considerably more than 10 per cent., this would mean a great saving of life. How, then, are we to measure the relative importance of these factors?

Quite recently the Local Government Board has issued a most valuable report on the subject of infant mortality,² mainly the work of Dr. Arthur Newsholme, the Board's principal medical officer, whose eminence, both as a vital statistician and hygienist, guarantees the care with which the work has been done. I am not concerned with the general aspects of this report, which contains much worthy of close attention, but I should like to quote a few sentences bearing upon the problem which immediately concerns us. Dr. Newsholme measured the correlation between the corrected birth rate and the infant death

¹ Westergaard, *Die Lehre v. d. Mortalität und Morbidität*, 1901, p. 403.

² Supplement to the Report of the Board's Medical Officer, 1910, Cd. 5263.

rate for 46 registration counties and found it to be .36; commenting upon this, he remarks: "Large families evidently do not necessarily imply a tendency to high infant mortality. They should *ceteris paribus*, except in circumstances of extreme poverty, have an opposite effect to a slight extent. The connection often observed between a high birth rate and a high rate of infant mortality probably is due in great part to the fact that large families are common among the poorest classes, and these classes are specially exposed to the degrading influences producing excessive infant mortality."¹

Should this conclusion be just, it would follow that the correlation between the birth rate and the rate of infant mortality ought to be much reduced if the factor of poverty could, by some means, be kept constant. Notwithstanding the eternal difficulty of finding a measure of poverty, it would seem that some approximation to the end in view might be hoped for through the use of the calculus of correlations. Apparently, however, no suitable data exist in this country, for neither poverty nor the prevalence of artificial feeding is brought into relation with infant mortality by means of the method of correlation in the Local Government Board report. A difficulty which confronts anyone attempting to solve the problem upon the basis of English official records are the size and heterogeneity of the conventional subdivisions, the registration counties. When it is a question of the general features of infant mortality all over the land (as was the case in the L.G.B. report), the objection may be of little moment. If, however, we set out to study the relative significance of the three factors enumerated, the introduction of such modifying conditions as greater or less urbanisation, differential employment in various industries and even climatic conditions increase the difficulties of our task.

For these reasons, it appeared necessary to find a set of communities not very different one from another in regard to the type of inhabitants, their occupations, and general conditions of life. With such material, a first study might begin and might suggest lines along which the general problem could be approached. To anyone familiar with the present state of

¹ *Op. cit.*, p. 49.

medical statistics, it is unnecessary to say that the conditions I have postulated are not fulfilled by any readily accessible collection of records. I did, however, obtain some material which approximated more closely to my requirements than any other figures I had seen. These data were particulars of the rural districts of the kingdom of Bavaria, published by Drs. Groth and Hahn in a recent paper.¹ In this work we have (1) the Birth Rate; (2) the Infant Death Rate; (3) the Poverty Rate, as measured by the proportion of persons in receipt of public assistance; (4) the Prevalence of Artificial Feeding, as indicated by the proportion of the children brought to the public vaccinators which had been bottle fed (in a large number of districts). Naturally these data are not ideal. The proportions of artificially fed children brought to the vaccinating stations only measure the prevalence of bottle feeding in a certain class of the population and even this datum is wanting in many districts. The measure of poverty, although superior to similar returns of pauperism in this country owing to the probably greater uniformity of the system in Germany, can easily be criticised. There are various other criticisms which will be found discussed elsewhere. Nevertheless, making the most liberal deductions from the face value of the data, I think something of interest can be extracted from them with regard to our present topic, and I shall describe certain results obtained on analysis by my assistant, Mr. J. W. Brown, and myself.

To begin with, we determined the correlation between the four variables taken in pairs, and then between each variable and the absolute population; lastly, the average correlations for a constant population were ascertained. For instance, the correlation between the poverty rate, as measured by Groth and Hahn, and the infant death rate was found; then the correlation between the population and the poverty rate of each district and between the former and the infant death rate. Finally we calculated the partial correlation between the infant death rate

¹ Groth and Hahn—*Die Säuglingsverhältnisse in Bayern*, München, 1910 (Lindauer) (*Sonderabdr. a.d. Zeit. d. K. Bayer. Stat. Landesamt*, Jahrg., 1910).

² Greenwood and Brown, "An Examination of Some Factors Influencing the Rate of Infant Mortality," *Journ. Hyg.*, 1912, Vol. XII., pp. 5-45.

and the poverty rate for a constant value of the population. This method, to some extent, corrects the error arising from the fact that we are correlating ratios and *pro tanto*, introducing some amount of possibly spurious correlation. Table II. contains the results deduced. The birth rate was based upon the total number of women aged 16-50 in each district, an imperfect method but somewhat superior to the ordinary crude birth rate. From these results, it appears that the rates of artificial feeding and birth are highly correlated with the infant death rate, which is also markedly but less closely associated with the poverty rate. We endeavoured to check these results against the values of similar coefficients deduced from other data, as will be seen in Tables III. and IV. Leaving on one side the coefficients based upon English registration countries and remembering the difficulties introduced by varying methods of measuring poverty and calculating birth rates, it is not clear that the comparison should lead us to discredit the coefficients obtained from Groth and Hahn's material.

We now come to the most interesting part of the work, viz., the relative importance of the different factors, and are at once brought face to face with a serious difficulty. In order to solve our problem we require the partial correlation between any two variables for constant values of the remaining two.¹ But, as seen in the table, the birth rate and the infant death rate can be correlated in 156 districts, the death rate and the prevalence of artificial feeding in only 97, no returns of artificial feeding being procured from the remaining 59 districts. If we confine ourselves to the districts in which all four measures are recorded, the data shrink to 84 entries.

If we use the total coefficients based upon varying numbers of districts, we disregard the possibility of some selective agency having been at work leading to failure of records for certain variables in certain districts, and there is also some difficulty in ascertaining the probable errors of the partial coefficients. If we confine ourselves to the 84 districts, we suffer the qualms of conscience which assail any statistician

¹ *i.e.*, a measure of the degree to which A and B are associated apart from the indirect association due to a correlation of A with C and of B with C.

who omits data from his series. Evidently the proper course to pursue is to calculate the partial coefficients in *both* ways and see how the results differ. We did this, and the important constants are given in Table V. The differences between the values yielded by the two sets of figures are of some theoretical interest, but I will confine myself to the conclusions which both methods agree in yielding.

They agree in placing poverty last in the scale of relative importance, and in classing the method of feeding and the birth rate as sensibly equal factors of the infant death rate, as measured by the coefficients of partial correlation. If we go a step farther, and attempt to connect changes in the death rate with changes in the other variables by means of a simple equation, then, owing to the fact that the proportion of artificially fed children varies much more from district to district than do either the birth or poverty rates, we find that the birth rate very definitely takes precedence of the method of feeding in order of importance. I do not, however, wish to lay stress upon this latter consideration—which is discussed at length in the memoir by Mr. Brown and myself—since its validity involves certain assumptions which may be questioned; confining ourselves to the coefficients of correlation alone, some reflections necessarily suggest themselves.

In the first place, while the absolute association of poverty, so far as this can be indicated by Groth and Hahn's measure, with the rate of infant mortality is considerable, the importance of the poverty rate as a factor is less than usually supposed. In the second place, there is room for considerable doubt as to whether, in the Bavarian rural districts, the prevalence of artificial feeding is more closely associated with infant mortality than is the birth rate. In other words, these data, so far as they go, hardly bear out the suggestion made in the Local Government Board's report as to the real genesis of the correlation between the birth and infant death rates. In itself, the correlation between the two rates might be looked on as a mere arithmetical curiosity, of no more importance than the number of postage stamps required to pave London Bridge; but if there is really any force in the contention that

inferior stocks are the more fertile, we cannot dismiss the results in this way. It is common knowledge that artificial restrictions upon fertility are employed to a considerable extent among the middle classes at the present time. It is fairly certain that this statement would not have been true fifty years ago. Let us suppose that it also holds for many of the efficient members of the working class. The result would be that fertility is now associated with mental and physical inferiority owing to the voluntary adoption of a certain line of conduct on the part of a section of the community. We should accordingly expect to find a difference between the correlations of birth and infant death rates as deduced from modern statistics or material of fifty years ago. This is precisely what Dr. Heron found in the case of the London boroughs. The correlation between the two rates was $+ \cdot 51 \pm \cdot 10$ for 1901 statistics, $- \cdot 30 \pm \cdot 10$ for the data of 1851.¹ It is, *a priori*, improbable that fertility in general would be associated with a lessened power of resistance on the part of the offspring since, were this to be the case, the evolution of a stable type would seem to be difficult (this I take to be the idea prompting the first sentence of the passage quoted from Dr. Newsholme's report). From data, probably little affected by artificial restrictions upon fertility, Beeton, Pearson, and Yule have shown that longevity and fertility are correlated,² and there is reason to suppose that longevity is a heritable character.³ It is not clear that fertility and the rate of mortality are generally associated. In the statistics of upper and middle class families discussed by Ansell in 1874⁴, for instance, out of 10,000 born, the following are the deaths in the first year of life in each of Ansell's classes: Clergy, 738; Legal, 797; Medical, 867; General, 843. The mean numbers of children to a marriage (including still-births) in each class are, in the same order, 5·36, 5·32, 4·96, 5·50. It is also clear

¹ Heron, *On the Relation of Fertility in Man to Social Status, etc.*, London, 1906, p. 18.

² Beeton, Pearson, and Yule, *Proc. Roy. Soc.*, LXXVII., 1901, p. 159.

³ Beeton and Pearson, *Proc. Roy. Soc.*, LXV., 1899, p. 290. *Biometrika*, I., 1901, p. 50.

⁴ C. Ansell, Jun., *Statistics of Families in the Upper and Professional Classes*, London, 1874.

from the international statistics collected by Prinzing¹ that changes from year to year in birth and infant death rates are by no means uniformly related.

The suggestion I am endeavouring to convey is that the correlation between the infant death and the birth rate is a phenomenon which may well be due to special circumstances, but that it is by no means lightly to be dismissed as a secondary consequence of some environmental factor readily amenable to administrative control. Granted that it is possible to free the poorest classes from those "degrading influences" referred to by Dr. Newsholme, it hardly seems to follow that the connection between a high birth rate and a high infant death rate will be broken.

Let us now pass to the high correlation between the prevalence of artificial feeding in Bavaria and the infant death rate.

Since there is ample room for improvement in the customary methods of hand feeding among the poorer classes, and since some at least of these improvements can be expedited by administrative reforms, the magnitude of the correlation affords us grounds for anticipating a reduction of the rate of infant mortality in the future as a consequence of environmental changes. That this is a justifiable hope, few will dispute, but we must bear in mind certain doubts which a close examination of the facts can hardly fail to produce. Altogether apart from purely statistical considerations, the subject is not free from ambiguities. Let us recur for a moment to the possibility that an incapacity to suckle may be an indication of some constitutional defect. If this be the case, and if further we admit that constitutional peculiarities are heritable, another question must be asked, viz., is the low resisting power of a bottle-fed infant entirely due to the form of its nourishment or may it be possible that inheritance comes into play? If we adopt the view that both factors are involved, how can their respective shares be determined?

There is some, perhaps not much, evidence that an incapacity to suckle is an inherited character. The well-known

¹ Prinzing, *Jahrbuch für Nationalökon. und Statistik*, III. F. Bd. XVII., 1899, p. 577.

physiologist, Prof. G. v. Bunge, has identified himself with this view. V. Bunge classified nursing mothers as “Befähigten,” or “nicht Befähigten,” let us say, efficient or inefficient nurses. The former group comprised the women who had nursed all or the majority of their children for at least nine months, a somewhat stringent qualification. He then distributed among his medical friends schedules with the object of obtaining statistical data. From the data published in his 1904 paper¹ I extracted the information given in Table VI., where a + sign indicates efficiency and a – sign inefficiency.

For various reasons, it hardly seemed desirable to spend much time in analysing v. Bunge's returns, but they suggest that the subject is one deserving more attention than it has apparently received in this country. Before we can confidently assert that the non-success of hand-fed children is simply an affair of environment, further study would seem to be essential.

We are now in a position to consider the import of the topics here mentioned. First of all, let us be clear as to what we are actually discussing. That feeding with pure milk is less dangerous than using dirty feeding bottles containing adulterated and septic milk, that a child, whatever its ancestry, brought up in a good home is more likely to survive than one entrusted to dirty and poverty-stricken persons, are palpable facts; to doubt about them is not to be sceptical but to be silly. But we have not to deal with elementary truisms of this kind. What we must ask is, whether, in such a world as the present, approximations to good or bad environmental conditions, possible in the existing state of society, are pre-potent factors of the infant death rate. Stated in this way, and I do not see in what other way the problem can fairly be stated, it will appear that our only hope of attaining to a solution is by means of statistical inquiry. The truth of this contention has been effectively admitted by nearly every writer. Almost every argument (leaving out of account platform speeches and other types of ecstatic literature) tending to show that the infant death rate is a function of the environment has been based upon or accompanied by statistical records. An examination of this

¹ V. Bunge, *Virch. Archiv.* CLXXV., 1904, p. 185.

class of literature would soften the condemnation a reader may be inclined to pronounce upon the inadequate character of the evidence here cited. For me to assert that I have demonstrated the incorrectness of accepted opinions would be absurd presumption. That, however, a belief in the necessity for care in interpreting the evidence before the public is not the whim of an unknown writer will be sufficiently proved by a quotation from the work of a distinguished authority, Dr. Westergaard. After remarking upon the apparent connection between fertility and infant mortality, Westergaard observes :—

“Here we have displayed a factor of as far-reaching importance as the method of feeding, and any inquiry into infant mortality in order to be based upon firm foundations must pay due regard to both factors, which is unfortunately in most cases impossible. Now, we must not lose sight of the fact that these two factors may themselves perhaps be in part only secondary phenomena. The artificial nourishment may be due to the mother’s weak constitution, in which event the higher death rate can partly be explained as an inherited stigma (*Belastung*). On the other side can be urged that feeding by a wet nurse, which is often due to the same cause, gives, according to Böckh’s inquiries, often very favourable results. Social and economic conditions may also intervene as correlative factors. And, with respect to the height of the birth rate, it is tempting to refer the increase of mortality partly to an overtaxing of the maternal organism partly to economic difficulties which often confront the attempt to supply favourable conditions of life for a large family; but we dare not overlook the fact that an opposing hypothesis can be advanced, viz., that it is not the many children which produce the abnormal mortality but conversely the high mortality which calls into being the numerous children in that the loss of children physiologically and psychologically renders possible and is associated with a further production of children. It is therefore necessary to burrow deeper in order to separate the individual factors one from the other; this at least stands firm, that where much life is sown still more death is sown, and in particular when the number of children greatly exceeds the average, death claims an abnormal harvest.”¹

This passage from the works of a learned and experienced statistician surely deserves notice. We may ask whether such considerations have always been in the minds of writers upon the subject and whether those who have the heavy and responsible task of educating public opinion might not do well to insist upon the necessity for caution and reserve in interpreting statistical data.

¹ Westergaard, *Die Lehre von der Mortalität und Morbidität*, Jena, 1901, p. 368.

If one looks at the problem not merely from the standpoint of the specialist who cannot, with the best will in the world, avoid a tendency to over-estimate the importance of conclusions apt to be elicited by processes which he admires and uses and to slight other equally important truths not reducible by his methods, there is still room for much more hesitation than seems fashionable.

What may be termed a collective sense of pity, the will to bring light to them that sit in darkness, to raise those who have been struck down in the battle of life, is a development of the national conscience which few, outside a tiny circle of extremists, would desire to arrest. Even were it true that public efforts to lower the rate of infant mortality by increasing the amount of attention officially devoted to nurslings did not produce all the results claimed for them, it does not follow that they should be diminished. But we must remember that the bulk of persons with whom ultimately the decision rests, those who find the money, are neither very highly educated nor very logically minded. If the public spirited men and women appealing to their fellow citizens on behalf of the children make exaggerated claims with respect to the measures they advocate, they may at first receive more support than would be accorded to modester pretensions. In the long run, however, a nemesis will overtake them. There will be the usual revulsion, the customary recoil from exaggerated credulity to exaggerated scepticism. Before now, useful therapeutic measures have been discredited in consequence of the exaggerated claims made on their behalf in the first flush of enthusiasm.

I firmly believe that all possible measures to improve sanitation, to improve the conditions of slum children, to minimise the chances of spreading infectious disease, the whole programme of the modern medical publicist, should be unflinchingly supported. If we wished to discredit them, the readiest means would be to go up and down the land asserting that by doing this or that, consumption can be "conquered"; that by spending a million here and creating an official there, infant mortality can be reduced by eighty per cent. And so, in the name of sanitary reform itself, I would plead for more criticism

of the arguments by which it is supported. At present there is far too much invective and too little discussion in connection with public health matters, signs of the temper which unhappily seem to characterise political controversies. It should be possible for students of science to discuss grave questions affecting the national welfare and to canvass differences of opinion without the use of any expressions which generate much heat and little light. We shall do wisely to live in the spirit of that phrase which Professor Karl Pearson chose as the motto of his famous "Grammar"—*la critique est la vie de la science*.

TABLE I.
Number out of 100,000 born who survive one year.

Country.	No. per 100,000.
Sweden	88,917
France	83,674
Belgium	83,114
England and Wales	82,814
Massachusetts	82,767
Holland	82,681
Italy	82,481
Germany	76,614
Austria	75,028

TABLE II.
Rural Districts of Bavaria.

Variables.	No. of Obs.	Coeff. of Correl. ¹
Infant Mortality and Birth Rate	156	$\cdot 709 \pm \cdot 027$
Infant Mortality and Poverty Rate	145	$\cdot 475 \pm \cdot 043$
Infant Mortality and Artificial F'd'g Rate	97	$\cdot 760 \pm \cdot 029$
Birth Rate and Poverty Rate	142	$\cdot 420 \pm \cdot 047$
Birth Rate and Artificial F'd'g Rate	92	$\cdot 474 \pm \cdot 054$
Poverty Rate and Artificial F'd'g Rate	87	$\cdot 379 \pm \cdot 062$

[DATA COLLECTED BY DRS. GROTH AND HAHN.]

¹ For the purposes of this study, it will be sufficient for the non-statistical reader to regard a coefficient of correlation as an arithmetical constant measuring the extent to which two characters tend to vary concomitantly. The coefficient lies between 0 and ± 1 ; the nearer the value comes to ± 1 , the closer the association (if the sign is positive, the characters increase together; if negative, the increase of one is associated with the decrease of the other). The fraction in the tables preceded by " \pm " is the "probable error," and but little weight ought to be assigned to any coefficient less, in absolute magnitude, than three times its probable error.

TABLE III.

Poverty and Birth Rates.

Data.	Nature of Birth Rate.	Measure of Poverty.	r.	Computer.
27 London Boroughs	% Married Women 15-54	General Labourers per 1,000	$\cdot 52 \pm \cdot 10$	Heron
„ „	„ „	Pawnbrokers, &c., per 1,000	$\cdot 62 \pm \cdot 08$	„
„ „	„ „	Prop. living more than 2 in a Room	$\cdot 70 \pm \cdot 07$	„
„ „	„ „	Prop. of Children aged 10-14 employed	$\cdot 66 \pm \cdot 07$	„
142 Rural Dis. Bavaria.	% All Women 16-50	% Publicly assisted persons.	$\cdot 44 \pm \cdot 05$	G. & B.
22 Districts of Hamburg.	% Married Women 15-45	% Dwellings rented less than 300 marks	$\cdot 88 \pm \cdot 03$	„
26 Districts of Leipzig.	% All Women 15-40	% Dwellings rented less than 250 marks	$\cdot 83 \pm \cdot 04$	„
26 Districts of Leipzig.	% All Women 15-40	% Dwellings less than 2 Heated Rooms	$\cdot 91 \pm \cdot 02$	„

TABLE IV.

Correlation of Birth—and Infant Death—Rate.

Source.	Computer.	Correlation.	Birth Rate.
27 London Boroughs	Heron	$\cdot 50 \pm \cdot 10$	Married Women 15.54
38 Cities Mass.	G. & B.	$\cdot 42 \pm \cdot 09$	Crude
704 Rural Districts German	G. & B.	$\cdot 58 \pm \cdot 02$	Crude
156 Rural Districts Bavarian	G. & B.	$\cdot 68 \pm \cdot 03$	All Women 16.50
143 Cities Saxon	G. & B.	$\cdot 42 \pm \cdot 05$	Crude
44 Reg. Counties English	Newsholme	$\cdot 36 \pm \cdot 09$	Corrected
44 Reg. Counties English	G. & B.	$\cdot 64 \pm \cdot 06$	All Women 15.45

TABLE V.

Partial Correlations of the Rate of Infant Mortality with other Variables.

Characters.	Correlation. Coefficients.	
	A Varied Totals.	B Select 84.
Infant Mortality and Birth Rate	$\cdot 57 \pm \cdot 05$	$\cdot 70 \pm \cdot 04$
Infant Mortality and Artificial F'd'g Rate	$\cdot 66 \pm \cdot 04$	$\cdot 62 \pm \cdot 05$
Infant Mortality and Poverty Rate	$\cdot 17 \pm \cdot 07$	$\cdot 32 \pm \cdot 07$

[RURAL DISTRICTS OF BAVARIA. GROTH AND HAHN.]

TABLE VI.

[G. v. Bunge, *Virch. Arch.* CLXXV. 185.]

MOTHERS.

DAUGHTERS.		+	—	
	+	422	1	423
	1	281	435	716
		703	436	1139

